CONTINUATION APPLICATION

FOR

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OF

STEPHEN P. HINES
A CITIZEN OF THE UNITED STATES OF AMERICA
AND A RESIDENT OF GLENDALE, CALIFORNIA

FOR

AERIAL-IMAGE DISPLAY SYSTEMS

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REFERENCE TO RELATED APPLICATION

This application is a continuation of Serial No. 09/687,618 filed October 13, 2000, which claims the benefit of the U.S. Provisional Patent Application Serial No. 60/159,223 filed October 13, 1999, and hereby claims the benefit of the embodiments therein and of the filing date thereof and is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Aerial-image displays in which an image of an object appears in space are intriguing whenever seen. Examples of aerial-images may be found in the following environments:

Example 1: theme parks having a haunted mansion with dancing skeletons;

Example 2: magical stage acts with apparent floating heads;

Example 3: motion picture illusions depicting ghostly figures.

Typically, these images are beyond reach of the observer and recognized to be an illusion and transitory so as not to be carefully examined by the observer. Seldom have such images been produced with such precision and detail that they convince the observer that they are the actual objects displayed. Likewise, seldom, if ever, are they displayed within reach of the observer who can try to touch them only to be surprised upon realizing that the three-dimensional image hangs in mid air. Hence, the term "aerial image". Likewise, it is not possible to my knowledge to produce an aerial-image of an object in which the observer, standing in one position, can see the object rotate

before his eyes and examine it in detail without having the actual object in reach.

Examples of aerial systems are disclosed in the following patents:

U.S. Patent 5,944,403 D. Krause August 31, 1999

U.S. Patent 4,348,187 M. Dotsko September 7, 1982

In the case of displaying retail merchandise, a perennial problem typically in the jewelry trade is to allow a prospective customer to visually examine the merchandise, such as jewelry, from all sides without touching the jewelry. Keep mind that in the sales effort, touching the jewelry has heretofore been necessary in most cases.

Employing an aerial-image of fine jewelry can eliminate the need to touch the jewelry by casual shoppers and also provides for security of the actual jewelry, while allowing the casual observer and potential customer to view it as completely as if they had the jewelry in their hands.

Likewise in the jewelry field, most retailers must remove fine jewelry from their display cases or windows at night and thereby forego the opportunity to display the fine jewelry through a show window or showcase while the jewelry is in a secure or remote location.

In the entertainment field, the aerial-image display can be used to provide a totally realistic image of a natural object in space, within reach of an observer, again without contact by the observer. The effect of the image appearing to be the actual object, but without the tactile feel when attempted to be touched, is a marvelous attention getter.

At trade shows, objects can be displayed and rapidly changed at the same location and the viewer sees the aerial-image and not the actual object in close

proximity as would be the case if the actual object were on display.

In the field of video games, a reasonably high degree of reality can be portrayed on a video screen; but by the very nature of the screen's presence, the player is intensely aware that the entire scene is on a video screen. Attempts have been made to enhance or disguise directly viewed video displays (usually CRT's) with unexciting results.

In the field of transportation, particularly aircraft and automobiles, the use of "heads up" displays are becoming popular. They involve complex optics, which display the instruments on the canopy of aircraft or windshields of automobiles. In accordance with this invention, such aerial-images may be displayed between the eyes of the pilot or driver and the canopy or windshield.

These are just a few examples of the application of this invention and are by no means all of the applications to which this invention may be applied.

In any situation where an accurate display of an object for a number of observers is needed, the aerial-image display of this invention is applicable. Other examples include various levels of education from elementary through graduate schools. In scientific and medical institutions, aerial-image displays, in accordance with this invention, may be an ideal teaching tool to present details to a number of students simultaneously with any of them being able to point to an area of the aerial-image corresponding to the area of the object displayed in full view of the other observers.

In accordance with this invention, the optics are extremely precise producing realistic images but not so complex that the aerial-image display of this invention may not be incorporated in day-to-day objects around the home, primarily for personal use.

An example is a bedroom clock, which displays the clock face in nearby space but without any interference with the observer should he enter the image space.

BRIEF DESCRIPTION OF THE DRAWING

This invention may be more clearly understood from the following detailed description and by reference to the drawing in which:

Fig. 1 is an isometric view of an aerial-display device in accordance with this invention in the form similar to the popular video game housings;

Fig. 2 is a rear three-quarter partly exploded isometric view of the housing of Fig. 1;

Fig. 3 is a vertical sectional view through the housing of Fig. 1 showing the relative positions of the optical elements of the invention when the source of the image to be displayed is a video screen showing the field rays defining the full field in dotted lines and the image rays in dashed lines;

Fig. 4 is a vertical sectional view of the embodiment of Fig. 1 designed to produce aerial-images of a physical object in either a fixed position or rotatable on a turntable;

Fig. 5 is a vertical sectional detail of the partially silvered beamsplitter and circular polarizer of this invention shown attached to their respective mounting boards;

Fig. 6 is an isometric view of the concave mirror mounting board and mirror;

Fig. 7 is a detailed view in section of the mounting arrangement for the concave mirror on its supporting board;

Fig. 8 is a front elevational view of the object turntable of Fig. 4;

Fig. 9 is a sectional view through a portion of the concave mirror used in this invention;

Fig. 10 is a front elevational view of the display device of Fig. 4 with the lower front housing partly broken away to illustrate the position of the internal lamps relative to the turntable and object to be displayed;

Fig. 11 is an isometric view of an alternative embodiment of this invention designed for aerial display without an image shelf;

Fig. 12 is an isometric view of a tabletop clock radio incorporating this invention ;

Fig. 13 is a vertical sectional view through a clock radio of Fig. 12;

Fig. 14 is an isometric view of a tabletop TV, which includes an aerial-image of the TV screen display utilizing this invention;

Fig. 15 is a vertical sectional view through the tabletop TV of Fig. 14;

Fig. 16 is a vertical sectional view through the housing of Fig. 1 showing a downward-facing concave mirror as a part of another embodiment;

Fig. 17 is a vertical sectional drawing through the housing of Fig. 1 showing two concave mirrors for improved brightness of this invention;

Fig. 18 is a vertical sectional view through a video display in which a video camera is incorporated to photograph small objects;

Fig. 19 is a vertical sectional view through a display showing a talking head projecting an image from a VCR or streaming media from, as an example, dedicated web site on the internet;

Fig. 20 is an alternate mirror configuration where the concave mirror is a flexible, metallized film mirror;

Fig. 21 is an alternate mirror configuration using a molded plastic concave mirror;

Fig. 22 shows a glass-topped display case or housing for use in retail stores; and

Fig. 23 is an isometric (perspective) view of the glass-topped display case of Fig. 22.

DETAILED DESCRIPTION OF THE INVENTION

In order to understand this invention, reference is now made to Figs. 1 through 3, which demonstrate its basic concept. Fig. 1 shows this invention as applied to an aerial-image display system, generally designated **10**, in the form which may be used for displaying objects, in the order of 12 inches in diameter as a practical maximum for this type of use.

The embodiment is contained within a housing, generally designated **11**, having a window opening **12** in the front face and an image shelf **13** on a support arm **14** secured to the front lower panel **15**. The housing **11** is enclosed by a left panel **16**, a top panel **20**, two front panels **26** at the top, and lower panel **15**, two rear panels **21** and **22**, of which only **21** appears in Fig. 1, a right panel **23**, and a lower step panel **24**. The housing **11** is closed at the bottom by a bottom panel **25** appearing in Fig. 2. The window opening **12** is located in upper front panel **26**. The panels mentioned so far, with the exception of panel **26**, are normally secured and not open during normal use or maintenance. The panel **26** is hinged at its lower edge to allow it to be opened for possible cleaning of certain of the optics, if required.

The image shelf **13** is used as a visual reference and as a support for props to enhance the illusion, such as a vase for flowers, which is normally expected to rest upon a support. The image shelf **13** and its support arm **14** are optional, and for many applications their presence is undesired and may be removed. Such an embodiment appears in Fig. 11.

In the embodiment shown in Figs. 1-3, each of the panels may be of plywood or

particleboard, typically covered with plastic lamination having suitable finish on the exterior as dictated by the environment. Most of the interior surfaces are finished in dull black to prevent unwanted reflections.

Referring again to Fig. 1, the stepped panel **24** includes a door **24D**, which provides access to an interior chamber designed to hold a VCR tape player providing the scene to be displayed on the video monitor of Fig. 3 described below.

Referring now specifically to Fig. 2, it may be seen that the interior of housing **11** includes basically a lower chamber or first region **30** in which the object to be displayed or the source of the image is located, and an upper chamber or second region **31**, in which the image from the source is transformed into the aerial-image, which appears outside of the window opening **12**. Within the lower chamber **30** is the support structure **32** resting on the base **25** and defining an electrical outlet chamber **33**, the VCR enclosure **34**, providing additional storage space **35**.

The lower chamber **30** and the upper chamber **31** are separated by platform **40**, including an image transfer opening **41**. The platform **40** provides physical support for an apertured mirror support board **42**, which is shown exploded to the rear but is normally located at the rear of the upper chamber **31** and is supported by brackets **43**, which are secured to the side walls **16** and **23**, respectively. The mirror mounting board **42** has a large central, circular opening **44** dimensioned to receive a concave mirror **45**.

The upper chamber **31** also encloses a frame **50** that is used to support a partially reflective-transmissive beamsplitter mirror **51** of Fig. 3. The frame **50** is secured at a lower edge to a bracket **49**, which is attached to platform **40** and top panel **20**. The positioning of this frame **50** is better seen in Figs. 3 and in detail in Fig. 5.

For an understanding of the optics of this invention, which makes possible the aerial-image outside of the housing **11**, reference is now made to Fig. 3. In this embodiment of Fig. 3, the source of the image to be displayed is a video monitor **60** that is supported by frame **61**. The source of the aerial-image electronic signal is the video tape player shown in enclosure **34**. The image from the video monitor **60** is directed upward toward partially silvered mirror **51**, i.e., partly reflective means which reflects part of the video monitor image to the concave mirror **45**. Mirror **45** reflects the image through the partly silvered mirror **51** and through window opening **12** outward and into focus at position **VI** above the image shelf **13** and approximately 18 inches in front of window opening **12** in this embodiment. The mirror **45** and partially silvered mirror **51** constitute means for generating and directing the aerial-image out of window **12**.

Viewers standing in front of the aerial-image displaying system **10**, within a horizontal audience angle of approximately 43 degrees, see an aerial-image appearing to be present above the image shelf. The viewer looks at window opening **12** and sees only a dark window **65**, without any view of the mirror **45**, of any image within the housing or any reflected image of the observer. These are accomplished by the presence in the window **65** of an anti-reflective coating on a glass laminated optical circular-polarizing window **65**. The circular-polarizing layer **CP** window **65** causes any external light entering the housing **10** to be cancelled after reflection by the mirror **45**.

Likewise, the observer sees no image of the mirror **45** or other interfering images, only the floating aerial-image is present in front of the housing **11**. It is, therefore, submitted that the combination of the image source, the concave mirror, and the circularly-polarized anti-reflection window cooperate to provide the aerial-image

without any disturbing unwanted images. The circular-polarizing layer **CP** prevents external ambient illumination from being used by the observer from viewing the internal optics, including the directing means mirror **45** and half-silvered mirror **51**. Although not mandatory, the anti-reflective coating **AR** prevents the observer from seeing his image reflected in the window **12**.

Because of the confined nature of the housing, cooling air openings **70** in the baseboard **25** are present. An exhaust port **71** and exhaust fan **72** at the top of chamber **30** are used to extract heat from the interior. In Fig. 3, the system **10** is shown with caster wheels **73** for mobility and also to elevate the base **25** above the supporting floor to aid in air movement.

Referring now to Fig. 4. The same basic system of this invention may be used in displaying actual objects, including the feature of showing them rotating in front of the observer and is accomplished by certain changes in the system. In each case where the identical component is used in Fig. 4 as in Figs. 1 through 3, the same reference numbers are used.

In this case, no video monitor or any of its components are required. Instead, a bracket **111** and turntable **112** are rotated by a motor **113**, which provides rotation at speeds such as 3 rpms. Any object **DO** located on bracket **114** will form an aerial-image **VI** as is shown above the image shelf **13** in as clear and complete detail as the object itself presents.

In this embodiment, a pair of lamps **115** and **116**, both of which appear in Fig. 10, illuminate the display object **DO**, but only lamp **115** appears in Fig. 4. The lamps **115** and **116** typically are of the internal reflector type, MR16, of lamp of 115V, 35 watt rating

to produce a bright view of the object **DO** with limited beam spreading. Since the display object **DO** is located on turntable **112**, the lamps **115** and **116** are directed at successive sides of the object, the image appears as in ordinary ambient conditions. With proper angular positioning of the two lamps **115** and **116**, the entire surface of the object visible to the observer is clearly illuminated. To view the opposite side, the observer need only wait until the object rotates.

In Fig. 4, similar to Fig. 3, the image rays are designated by dashed lines from the object to the concave mirror **45**, through the partially reflective mirror **51**, through the front window **65** with its circular polarized and anti-reflective coated glass **12**.

Objects to be displayed can be placed on the turntable with the turntable motor inoperative to provide the static aerial-image of the display object.

One of the key elements of the optical system of this invention is mirror **45**, which is simple and effective. The mirror is made of glass with precision curvature and reflective front surface coating to provide an accurate image. The mirror is concave with the focal point at or near the image location **VI**. The mirror is of generally rectangular shape when viewed from the front. The rectangular shape is defined by the shape available within a housing **11** to make it as large as possible and to provide a large, high-quality image. A highly reflective coating is used because of the inherent loss of light, due to the inefficiency of the beamsplitter mirror **51**. A spherical shape is preferred, although other concave shapes may be used.

The mounting details of the mirror **45** may be better seen in Fig. 9 where the mounting board **42** includes the circular opening **44** and the mirror **45**, being concave and circular, rests in the opening **44** and is secured in place by a bead **80** of flexible

adhesive, such as silicone cement, in which the mirror rests. There is substantial surface contact behind the face of the mirror with the silicone adhesive in good contact between the inside surface of the board **42** and at the inside of the opening **44**. This also provides a degree of shock mounting of the mirror, while precisely holding the mirror in place.

The turntable assembly of Fig. 4 may best be seen when viewed from the front side in Fig. 8. It is mounted on bracket **111** with the turntable **112** itself constituting a flat plate of diameter that is determined by the weight of the objects to be carried. Lightweight objects, e.g., 10 lbs. or less, can be supported on a turntable broader than one shown in Fig. 8, which is 11 inches in diameter. The bracket **111** is not to be seen by the observer so it must be totally concealed below the display object **DO**. Likewise, the turntable **112** is not intended to be seen. Therefore, it is painted a dull black to blend in with the other background surfaces.

Positioned directly below the turntable is a direct drive motor **113**. The motor **113** may be of variable speed or single speed. I have found that the single speed of three revolutions per minute is most effective for displaying objects for close examination and for dramatic effect. It is possible for the observer to examine objects with a magnifying glass for remarkable realism.

Reference is again made to Figs. 4 and 5 showing details of the optical elements of the system **110**. Front window **65**, with its anti-reflective front layer **AR** and its circular-polarize **CP**, is viewed by the observer as dark glass in the front opening **12** of the upper panel **26**. Behind that front window **65** is the partially reflective mirror **51** in its frame **50**, which is installed at approximately an 50 degree angle with respect to the

horizontal axis **CL** of mirror **45**. These angles are determined primarily with respect to the desire to minimize the housing **11** depth, and this does not effect the optical properties of the system when kept within the angular limits of the field rays with respect to the axis **CL**.

Fig. 4 also shows field rays **FR** which define the limits of field of the system **110** in which the image rays of the actual object must fall. The window **65** is a high-grade glass with an anti-reflective front surface **AR** and laminating the circular polarizer **CP**. The window **65** is secured by brackets **49** to the front top panel **26**. Note, as best seen in Fig. 5, that the panel **26** is hinged at its bottom edge to the remainder of the housing **11** at frame member **49**. The angled frame **50** is also secured to frame **49** at its lower end, and at its upper edge, which is not shown in Fig. 5, to the underside of the top panel **20** of the housing **11** at the required angle.

Fig. 10 illustrates clearly the lamps **115** and **116** directed at approximately 45-degree angles with their beams directed at the display object **DO** on turntable **112**. When the power cords **115PC** and **116PC** from the lamps **115** and **116** are connected to outlet boxes, the lamps **115** and **116** may be energized. When the power cord **PC** from the turntable motor **113**, and shown in Figs. 4 and 10, is connected to one of a number of power outlet boxes contained within the housing **11** and energized, the turntable rotates under the light of lamps **115** and **116**. These are all viewable in Figs. 4 and 10 with lower front panel **15** partly broken away. Fig. 4 also shows hinges shown in dashed lines and the latch is for the top front panel **26**.

Fig. 11 illustrates either of the embodiments of Figs. 3 or 4 without any image shelf **13** or support **14**.

As is described above in the background of the invention, this invention has application in many fields. Figs. 12 and 13 illustrate just such an application for home appliances, a bedroom or den clock radio, or for that matter usable in offices as well. The clock radio, generally designated **120**, includes the normal radio controls of an ON/OFF switch and volume control **121**, a tuning knob **122**, and possibly a band selector switch on the near side.

An internal loudspeaker is positioned behind the speaker grill **124** in the form of an array of holes in the case **125**. The only departure from conventional clock radios in the appearance is the fact that the normal bezel or cover for the hands is replace by a window **126**. The window **126** is not apparently transparent but presents a dark appearance to the observer within the field of view of this invention.

By incorporating this invention, the clock portion of the clock radio **120** appears as the aerial-image **VI** of a clock face and hands in space in front of the window **126**. The aerial-mage **VI** will be spaced in front of the window and viewable by observers within the viewing angle of the window **126**.

Referring now to Fig. 13, it may be seen that the same optical elements found in the embodiments of Figs. 3 and 4 are present in this clock radio only on a smaller scale. The window **126** exhibits an anti-reflective coating **AR** on the outer face and a glass laminated circular polarizer **CP**. This window **126** thereby prevents the viewer from seeing his own image reflected in the window, allows the aerial-image to be transmitted and circularly polarizes any external light that does enter the window and reach the internal concave mirror surface **130** from being reflected back into the room. The mirror **130** is formed as a part of the case **125** and metallized after the molding process in

accordance with established metallizing practice.

Within the case **120** at an angle is a partially silvered beamsplitter **131**, similar to the beamsplitter **50** of Figs 3 and 4. The lower half of the case includes the clock motor **132**, with its face **133** and hands **134**. Power for the clock motor **132** is supplied via leads **CL**.

One or more miniature lamps **140** are mounted on the rear wall **141** directed toward the clock face **133** to illuminate the clock face **133** and hands **134**. The circuit board and components in the base of the case **125** represent the radio **150**; and the loud speaker **151** is shown attached to the front wall of the case **125** behind the grill openings.

Now for a disclosure of another embodiment of this invention, please refer to Figs. 12 and 13. Fig. 12 is an isometric view of a personal aerial-image display device, such as a tabletop clock radio **120**, incorporating the aerial-image optics used in other versions of this invention. A aerial-image **VI** of clock hands and hour markers **134** of Fig. 13 can be seen floating off the face of the housing or case **125**, formed by light rays emerging through window **126**. The radio contained within the housing is of conventional design, including an ON-OFF switch and volume control **121**, band selector switch (not shown in the drawing) tuning knob **122** appearing in Fig. 12, and tuning indicator **123** appearing in Fig. 13.

Fig. 13 is a vertical sectional view through the personal aerial-image display device **120** of Fig. 12. In Fig. 13, the displayed object is the clock **132** with a face **133** and hands **134** horizontally mounted and illuminated internally by lamp **140**.

Light travels vertically upward where it reflects off of a 45-degree beamsplitter

horizontally rearward toward to a concave mirror **130** that is molded as part of the housing **141** and metallized. Light, which is focused by and reflects forward from the concave mirror **130**, is transmitted through the beamsplitter **131** and through circular polarizing filter **CP** through front window **126** to form aerial-image **VI**.

Still another embodiment of this invention may be seen in Figs. 14 and 15. Fig. 14 is an isometric view of a personal aerial-image display device, such as a tabletop television **120TV**, incorporating the aerial-image optics used in other versions of this invention. A aerial-image **VI** of the liquid crystal display (LCD) television screen of Fig. 15 can be seen in Fig. 14 floating off the face of the television set **120TV**, formed by light rays emerging through window **126**.

Fig. 15 is a vertical sectional view through the personal aerial-image display device of Fig. 14. In Fig. 15, the displayed object is the video display, which has built-in illumination. Light travels vertically upward where it reflects off of a 45-degree beamsplitter horizontally rearward toward to a concave mirror **130** which, similar to the radio embodiment of Figs. 12 and 13, is molded as part of the housing **141** and metallized. Light, which is focused by and reflects forward from, the concave mirror **130** is transmitted through the beamsplitter **131** and through circular polarizing filter **CP** through front window **126** to form aerial-image **VI**.

This display may be any type of video display, such as a cathode ray tube (CRT), a liquid crystal display (LCD), or such newer displays which become available, such as the organic light-emitting diode (OLED) display.

Illustrating some of the versatility in design of this invention are Figs. 16 and 17. Fig. 16 is a vertical section drawing through the housing of Fig. 1, showing a video

monitor **60** as an image source, with one concave mirror facing downward rather than facing the window as in the previous embodiment.

In a previous version, Figs. 2-4 and 12, only one concave mirror was used to form the image. In this system, light traveling upward from the object **60** is transmitted through the 45-degree beamsplitter upward toward concave mirror **45**, which reflects it downward to be reflected off the 45-degree beamsplitter forward through the window or opening **12** and circular polarizing filter to form the floating image (aerial- image) **VI**.

Fig. 16 illustrates that the concave mirror has at least two different candidate locations to accommodate different housing limitations, while maintaining the same optical properties as the embodiment of Figs. 2-4.

Where image brightness is an important factor, the embodiment of the invention shown in Fig. 17 becomes the preferred embodiment. Fig. 17 is a vertical section drawing through the housing **125** of Fig. 1 showing a video monitor **60** as an image source, and with two concave mirrors **45a** and **45b** to double the brightness of the display. In previous versions, Figs. 2-4 and 12, only one concave mirror was used to form the image; however, Fig. 17 shows two mirrors in optically equivalent positions which cooperate to relay the image out in space. In the case of forward-facing mirrors **45a**, light goes vertically upward from the object **60**, reflects off the 45-degree beamsplitter horizontally rearward toward concave mirror **45a**, which reflects it horizontally forward through the beamsplitter **51**, window **12**, and circular polarizing filter to form the floating image (aerial-image) **VI**.

In the case of concave mirror **45b**, light goes vertically upward from the object **60**, is transmitted through the 45-degree beamsplitter **51**, upward toward concave mirror

45b, which reflects it downward to be reflected off the 45-degree beamsplitter forward through the window **12** and circular polarizing filter to form the floating image (aerial-image) **VI**. In the previously described designs of Figs. 2-4 and 12, this light would have been lost and absorbed in the black underside of the top **20** of the housing **110**.

Fig. 18 solves the problem encountered by retail merchants who want to display objects, such as jewelry, which are physically too small to be seen effectively from a distance. Fig. 18 is a vertical section view through a video version of an aerial-image display **110**, in which there is a section where a small video camera **VC** is position to photograph small objects **DO** on miniature turntable **113**, and illuminated by light source **115**, all of which is light baffled in a separate chamber from the video display.

In operation, the merchant removes the rear access door **22** and places the displayed object **DO** on the turntable **113** and replaces door **22**. The video camera is pre-focused on the middle of the turntable **113** where the displayed object **DO** is placed. The video signal from the camera **VC** goes to the video monitor **61** that displays a large image, which is relayed to position **VI** by the same optics as is used in the embodiments of Figs. 2-4 and 16 or 17.

In the case where a human illusion is desired, the embodiment of Fig. 19 is recommended. Fig. 19 is a vertical sectional view through an aerial-image display **110** showing an illusion to create a talking head at aerial-image position **VI**. The optics using beamsplitter **51**, and concave mirror **45a**, and circular polarizing filter **CP** are as described before. A molded head is the displayed object **DO**. This head can be translucent and back projected with a video image from video projector **VP** as shown, or opaque and front projected by a video projector (not shown). In the preferred

configuration as shown, the head **DO** is molded or vacuum formed, translucent plastic without much detail in the facial features. This makes the generic head more adaptable to having a variety of people's faces projected onto the back side of the molded head, which acts like a rear-projection screen.

The video image can come from an internal VCR (shown in Fig. 3); however, this video-projector version has the advantage of being able to project streaming video and audio from a dedicated internet web site. In a situation where a large chain store operation would have displays in many chain stores or fast-food restaurants, the video image of a celebrity or recognizable character (Fig. 19A) could be video projected onto the molded face, which would be relayed optically outside of the display. This gives the sponsor the opportunity to change the video message, or the person, at any time from their headquarters. To enhance the illusion, a headless mannequin **HM**, appropriate garbed, can be placed in front of the aerial-image housing **110** to complete the human figure. If the head **DO** is of flexible material, including opening lips, the head may be synchronized with audio, which can make the human figure appear life-like while speaking.

As an alternative, as illustrated in Fig. 19, in combination with Fig. 19A, it is possible to employ a live actor in front of a video camera speaking the lines, which constitutes the audio channel that may communicate with the aerial display of Fig. 19 via a suitable communication channel which may be any of a number of dedicated channels or may be via the Internet as indicated by the "www." indication on the TV cable of Fig. 19A.

Figs. 20 and 21 illustrate alternate forms of concave mirrors that may be used in

carrying out this invention. Fig. 20 is an alternate mirror construction where the concave mirror **45** is made from a thin membrane or sheet **45F** of aluminized film, such as the polyester material sold by the The DuPont Co. under the trademark Mylar™. The Mylar ™ mirror can be pulled into a concave curve, nominally a partial spherical shape, by an exhaust fan **70** shown in an otherwise sealed chamber behind the film sheet **45**, or pushed into shape with a pressurizing fan (not shown), but otherwise located on the front (concave) side of the mirror **45F**. This film mirror **45F** has an advantage of being very lightweight and inexpensive, as compared with many mirrors of the size and quality required.

Fig. 21 is an alternate mirror configuration where the concave mirror **45M** is a molded plastic, concave shape, that has been coated with aluminum or other bright metal to form a mirror surface. Plastic mirrors are lighter weight, for the same thickness, and less susceptible to breakabe than glass mirrors.

Fig. 22 shows a glass or otherwise transparent-topped display case **200** for use in retail stores (camera and jewelry stores, etc.). The displayed object **DO** is enclosed in a secure cabinet **210** and illuminated by light source **215** located, for example, on a side wall and outside of the optical path from the displayed object **DO** to the optics of the system.

Light reflected off of the displayed object **DO** reflects off the underside of the partially reflective, and partially transparent, beamsplitter **251**, and reflects down toward concave mirror **245** which focuses and reflects the light upward at a forward angle through beamsplitter **251**, then through circular polarizing filter **265**, and through the horizontal glass top to form aerial-image **VI**. The user unlocks and removes the access

door **222** and places the product **DO** on a turntable **212** which is rotated by a motor **213**. Switches on the back turn power on to fans (not shown), lamp(s) **215**, and turntable motor **213**. Circular polarizing filter **265** virtually blocks all room illumination, including the observer's own image, from being reflected and visible in the concave mirror **245**.

Fig. 23 is an isometric view of the glass-topped counter height, e.g., 30"-42" height, display case **210** of Fig. 22. Visible are the air entrance holes **270**, product-access door **222**, the glass top, and openings in the opaque horizontal top surface, just under the glass, through which light emerges to form the aerial-image **VI**. Note that the beamsplitter or partly silvered mirror **251** is now positioned generally parallel to the glass top which acts as the window. The approximately 45-degree angular relationships of the beamsplitter are maintained with the object **DO** and the mirror **245**.

This embodiment is particularly suitable for the display of valuable items that may be damaged by excessive handling or of such value that security is of prime importance. The aerial-image produced by this invention is so realistic that one is tempted to, and usually does, reach out in an attempt to touch it, only to their amazement witness their hand pass completely through the displayed object image.

Employing the embodiments of Figs. 14 and 15, it is possible to obtain a version of 3D images by combining this invention with the AUTOSTEREOSCOPIC IMAGING SYSTEM of my U.S. Patent 5,430,474, issued July 4, 1995, the contents of which are incorporated by reference in this application. A copy of this U.S. Patent 5,430,474 accompanies this application.

The foregoing describes the principals of this invention and four different embodiments, all of which produce an intriguing image or images of different objects

with precise detail and within the reach of the observer. The foregoing embodiments are representative of this invention but are not intended to be limiting. Rather the invention is defined by the scope of claims allowed in the resulting patent including the protection afforded by the Doctrine of Equivalents.